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ABSTRACT

This paper argues that the search for and development of talent in science and mathematics must not be so circumscribed that every young person found with that talent be captured for science and mathematics careers. Talented youth should also be prepared for broader roles in the betterment of society. Leadership needs to be strengthened, in the hope that society might be better governed. Studies of top leaders indicate that good leaders need to learn, to be tested by experience, and to examine and review what they learned. To make this happen, it is necessary to attract into leadership responsibilities talented and well-educated persons, by offering talented youth a broad and liberal education that builds commitment and concern, an understanding of our social institutions, and an ability to engage the rigorous and analytical processes that characterize good science. Earl Dowell offers a reaction to the paper by exploring the backgrounds of such leaders as U.S. Presidents and chief executive officers of major corporations, and also comments briefly on career selection of young people. Edward Sherburne, Jr. argues that the use of academic achievement to identify talent is too restrictive, and offers several recommendations to identify other forms of talent. (JDD)

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THE IMPORTANCE OF DEVELOPING LEADERSHIP POTENTIAL OF YOUTH WITH TALENT IN MATHEMATICS AND SCIENCE

Kenneth E. Clark

This conference is addressing critical issues with regard to the identification, motivation and development, and the tracking of academic talent. Important matters of policy rest on these discussions. We have heard again and again of the vital role of the talented in the fulfillment of the world's plans for a better life and a better society. Unless we identify and nurture this portion of each generation we will fall short of our goals, for our societies must rely on this talent for the solution of its problems. I am delighted to be a member of this group addressing this important issue and fully support its purposes.

I make this introductory statement because the theme of my talk is somewhat different from what many of you have been considering. I will argue that the search for and development of talent in science and mathematics must not be so circumscribed that every young person found with that talent be captured for science and mathematics careers. No one has suggested that, but the current scarcity of talent in these areas surely tempts us to be zealous, maybe too zealous in our protection and use of this rare talent. My point will be that persons with these talents also possess other talents that must also be nurtured, and that our society will gain more if many of our very best youth commit themselves not only to excellence in science careers, but also prepare for broader roles in the betterment of our society. I will base my talk partly on psychological data about human qualities, and partly on a growing set of data about leadership qualities and how they develop.

My hope is that attention to other talents will help us to broaden our thinking a bit.

I am an industrial/organizational psychologist interested in the ways in which people choose lifetime careers and in the way these careers develop. I think it might be useful for all of us to keep the discussions of these three days within a perspective that draws on what is known about human qualities and the way they emerge or develop. I will give you a number of generally accepted propositions.

1. Human characteristics vary. Most people are near average. We all know that well--in fact, the differences among persons is the very reason for our conference. When psychological measures of various attributes are developed and use to obtain scores on populations of humans, the form of the variation generally matches the Gaussian curve, with most measures clustering around the middle, or the mean, with fewer and fewer measures being found as one moves farther and farther from the mean. Most people are near the average on most characteristics. When we start searching for persons who have the prospect of truly advancing knowledge, we must talk in terms of relatively small numbers.

2. All socially desired qualities are positively correlated within a society. It is not our business today to examine why this is, but the statement is true for all societies and all socially desired samples--the correlations are higher than most of us want to believe--generally ranging around .30. When the qualities are school-related, the correlations are much higher; when they are experience-related, they drop. The implications of this phenomenon are obvious. The talented in mathematics and science are often talented in other areas as well. If we draw

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out the science-talented, we draw a larger than average proportion of persons talented in other areas as well.

3. If talent is paramount, we cannot be egalitarian. Great talent is not distributed evenly over various strata of society. More talent is found among the most prosperous; least among the poor. However we shape our programs for the talented, we will be accused of elitism and discrimination. Even if our purpose is to give equal opportunity to every person from every walk of life, we will not end up with equal representation from each walk of life. If we insist on that outcome, society will pay quite a price in lost talent.

4. Great talent can be found in all segments of our society. Even when substantial differences may be found between groups, the differences within groups are always greater. That is true for all valued human qualities. If our society restricts its opportunities only to the groups already evidencing success, we will pay quite a cost in terms of loss of talent. We will also have violated one of our fundamental values.

5. Talent is not something that is 'just there' waiting to be found. One need not enter the argument about heredity versus environment to come to this conclusion. The simple point is that talent in science emerges and is identified only as exposure to the subject matter occurs--whether by teaching or by exposure to problems needing solution. Only when opportunity presents itself will such talents be discovered. Only when sufficient challenge is present will the quality of the talent be estimable. Only as adequate guidance in learning is available will it be possible to discover the ultimate limits of talent. This point emphasizes what many of you have already said--that in the absence of challenge one cannot even guess at the loss of talent in a society.

6. Talent that is undiscovered or underdeveloped is our major problem. Society does not improve by virtue of the *latent* talent of its members, it improves by the works--their actions. To translate talent into useful acts, into creation, into change, into discovery is our goal. For a person to lead a useful life that takes advantage of latent talents to the utmost requires more than just the discovery and development of talent. It also requires a system that provides assignments for work, support for that work, increasing challenges, opportunities for increase in scope for responsibility, opportunities to take on tasks from the start, opportunities to stop and reflect, and opportunities to develop strengths into greater strengths, to discover one's weaknesses, and to find how those weak areas may be handled so as not to set limits on one's achievements. If we do not provide these opportunities and challenges, we again pay quite a price in loss of talent.

7. The choice of one's life work is among the most important choices an individual makes. That choice determines in large part one's identity, one's self-image. It says something about one's life's aspirations, and the values held highest. Choice of career can be predicted twice as accurately by inquiring about one's preferences for specific work activities as by measuring one's abilities. Intrinsic interest in a given type of work will more likely lead to creativity in that work, and continuance of employment in that line of work.

8. Learning by top performers is lifelong. A very high proportion of learning that undergirds useful performance on the job is acquired after leaving school. It is as important to continue learning on the job in order to be effective as it is to learn all those needed bits of knowledge and the skills that are taught in our institutions of learning. We have seen in our society and others that much of what is learned on the job can be destructive---by undermining commitment, by reducing aspirations, by heightening stress, or by sheer dispiritment produced by oppressive environments. Fortunate are those persons whose work continues to interest and to challenge them throughout the work life, and those societies that provide for their people such interest and challenge.

9. Highly successful adults change a lot during midlife. Human qualities do not develop and mature only during the formative years--say up to age 25--and then stay the same until the ravages of life are seen in senile deterioration. One's abilities, character, and personality change through the midlife period, sometimes resulting from, sometimes leading to distinctive shifts in jobs, locale, family circumstances, and values. Without the forces leading to growth and development, the midlife period may become one of dullness and misery. For most people, responding to new assignments and challenges, being given opportunities to be innovative and creative, and even living through personal crises and hardship helps them to redefine their values and goals making their lives continually interesting.

The preceding statements did not come just from studies of mathematicians and scientists, but you can see their applicability. Instead, they came from studies of students; of tradesmen; of professional persons; of salesmen; of leaders, executives, and managers; and of the work forces that reported to them. Some have come from recent studies aimed at understanding how effective leaders get their jobs done, and how they learned to change their behavior dramatically in order to become more effective.

These propositions remind us that we must be concerned not merely with the identification of those youth who demonstrate potential for high performance in science and mathematics. We must also give them the opportunity to develop these talents, and all the other talents they possess. If large numbers of these youth are to pursue careers in science, they must not only know that jobs exist, but that such careers will be fully rewarding to them--in money, satisfaction and challenge. Every opportunity must be provided to learn more, to discover, to respond to problems in new and creative ways. If we truly prize the talents of our people, we must provide every opportunity for the continued development of talent throughout the life span. Our society probably does this better than any other society, but we all know how poorly the system works for many people.

Every society has addressed in some way this issue of use of talent. Since the beginning of mankind, life for each human has improved only as people have joined together for their common good. The quality of life improved as new tools were invented, as ways of controlling the environment were discovered, and as the special capabilities of individuals were exploited. The craftsmen soon gained stature as their crafts made life easier. Leadership and authority were yielded to the strong and powerful, or to the wise, or to those born to the purpose, or to those who were seen as chosen. As civilization progressed, the young were taught

the skills and crafts of the parents. For those youngsters born of the leader, or later, into royalty, training for leadership began almost at birth. Any youngster could have told you what he (rarely she) was going to be when he grew up--he would take over his father's craft. The mason's son became a mason, the carpenter's son a carpenter, the prince would become a king.

The American republic was founded on a new set of principles--principles of freedom and equality that gave high priority to opportunity, and to the idea of an open society--a society in which any person would be free to seek any goal, with no preferment to any. This new government also denied the right to inheritance of positions carrying power and authority. And the old-country laws on rights of the first-born were abandoned. The freedom not to follow in one's father's footsteps--critical to establishing an open society--also meant the loss of rights of the eldest son to inherit the father's position of power and authority. In one bold step, the new Republic declared an open competition for all positions in which the incumbent was authorized to enact laws and govern in the name of the people.

Those of us at this conference take for granted some of the unique aspects of our society. We have a few unspoken assumptions: that there are talents to be developed throughout all levels of our society; that these talents are of great value, and must be discovered and used if our society is to survive and prosper; that possessors of talent are free to use these talents in any way they want; that a wise society will assign its rewards and gratifications so as to assure that a sufficient number of them choose activities that will promote society's most critical goals.

Our founding fathers included plans for a program of public education in which all citizens became informed so as to give meaningful consent to being governed. All citizens were to be able to read and write, to have a minimal sense of history and the values upon which this society was founded and to understand their role in yielding power and authority to a group of leaders who would always be accountable to the electorate they served.

These wise men also recognized that those elected to hold the reins of government as representatives of the people would also need appropriate education. If young members of royal families had needed years of preparation before ascension to the throne, so, too, would an entire corps of potential leaders in the new Republic. These founding fathers were the elite of their times; their expectation surely was that a similar elite would be maintained and prepared for positions of leadership by higher forms of college education of the sort they had experienced.

The task of governance has become more complex as those who lead have neither royal blood nor a divine right to sanction their every act. And if consent of the governed is to be expected on issues of all sorts, solutions attained solely by the display of force will not do. Gaining acceptance of decisions--not just enforcing them--requires that leaders not only be highly intelligent, but also deeply committed to the cause of freedom, understanding of the ways of compromise, and endowed with enormous patience and forbearance.

Over the years, our society has asked our educational institutions to help in many ways. After Sputnik, our schools and colleges were central in the race to put a man on the moon. They were the major battle grounds in the war over civil rights--almost one hundred years after the slaves were freed, and almost fifty after women were given the vote. They are providing the major base for that research and development that undergirds our efforts to compete worldwide with our products, now that other nations have become competitive. When business or government puts up the support money, our schools and colleges turn to preparing more specialists in given fields, or turn to their research and scholarly interests into the desired areas of study.

We have come to expect that the educational system will change the direction of interests of students to match the needs of society. We have seen programs to give stipends to graduate students if only they will study mathematics or physics or molecular biology or engineering. Our news columns fill with statements from the Secretary of Education telling us all what students should study, and what he thinks a good curriculum should look like. These admonitions are drowned out by the multitude of messages with money attached--how much a Harvard MBA earns in his first year on Wall Street--what new BS's in engineering get--how much of a stipend a bright MD-PhD aspirant can receive. Our students are not stupid--they read society's priorities correctly--and go where the money is, especially to where the highest paying jobs are. Their ideals and their self-knowledge about interests and talents will moderate their responses to the message about priorities, but exhortations do not.

This conference is concerned with better use of the talent of the next generation so that we may strengthen science and technology in the service of mankind. I want you to add to your thinking the goal of strengthening our leadership, in the hope that our society might be better governed, and that leadership might be more effective. Both quests involve the same target population--the best and the brightest of our youth. Are these goals compatible, or is my suggestion a distraction?

When I speak of leadership and leadership responsibilities, I am speaking not so much about being president of the United States or president of a major corporation as I am about several millions of persons who understand what our society is all about, who cherish its values, and who see the defects that need correction, and the cracks in the system that interfere with effective functioning. Some who resonate within themselves to the near-misery of many of their peers, and who seek to improve the system to reduce that misery. These are the ones who make a difference. Some people call them change-agents. The correct word is leader--creative leader--an inducer of change for the good of all.

Warren Bennis interviewed 90 CEO's of major corporations. He was surprised by the diversity among the ninety. There were some common elements, but no one possessed all the good qualities; many who possessed some of the elements were in no way leaders. That has been one error of the past--to assume that leaders are alike. People we view as leaders say, "I had to learn a lot." Many become leaders much to the surprise of those who knew them in earlier years. Highly successful scientists are not out of place in such a population. In fact, they stand out.

McCall, Lombardo and Morrison asked top leaders in the corporate world to describe the experiences that taught them something; they reported: having to do something new and difficult, maybe on their own, a jump in the scope of the job, a challenge to save a failing business unit, starting up something new in strange surroundings, having to review their own goals and achievements while wondering whether they have been sidetracked or passed-over, being assigned to work for a four-square bastard, living through personal trauma, deaths in family, or divorce. These events teach--and change behavior--and seem to lead to improved effectiveness in leadership.

McCall and his group also examined what was learned from such experiences. They found that particular experiences taught particular things, and that those who had the most trying times usually learned the most. The learning often was a learning to balance--to balance self-confidence against an awareness of one's weaknesses; to balance a willingness to do some things one's self, while also learning to delegate well; to balance the goals of the organization against the needs of the persons in it; to balance collection of information from all sources, but be able to make decisions at the right time, before all possible evidence is in.

Studies like these of the lives of top leaders in industry say that good leaders need to learn, to be tested by experience, and then to examine and review what they learned. Those who did learn are seen to have developed an unusual sensitivity to the way the world and its people operate, with a sensitivity especially to those behaviors that result in one's gaining the respect and trust of others. Equally bright persons having similar experiences differ enormously in what they learn, i.e., in how much they change their own behavior in order to become more effective in leadership roles. Some never learn to change their behavior, and thereby set limits on their own growth and success.

Positions of leadership require certain prerequisite abilities: good mental functioning including a good memory, good problem solving ability, and the abilities to communicate and persuade; excellent cognitive functioning; and an ability to see interconnections, to notice parallels, to spot inconsistencies . . . to find ways to get a handle on a seemingly intractable problem.

These are the qualities we look for and that we seek to develop in our young scientists. These qualities are well developed and nourished in good pre-college educational programs and in an undergraduate education of high quality. But this list is incomplete for leaders--for the leader who is to serve best must also understand our traditions and our highest values, and must somewhere have acquired a commitment to put the good of all, and the preservation of our most fundamental values at highest personal priority. It is not also incomplete for our best scientists?

Would not our scientists and mathematicians be better off if a component of their undergraduate education was identical to that for persons electing to prepare for leadership? Should we ever say that we would rather have more scientists than have better leaders? Should those persons talented enough to make major contributions to science and mathematics ever be asked to avoid their citizenship responsibilities and the likelihood of leadership roles?

For my money, the four years of undergraduate education should be full of challenges. Challenges that are real, in that the student is expected to perform at the highest level of competence in a wide variety of scholarly and scientific efforts. By the end of the four years the student should have learned something--but no test is adequate to measure the learning I hope for. I would ask that every graduate know by the end of the four years his or her strengths and weakness, the domains in which talent is great and where it is least, and the work that excites and entrances, as well as the work that seems boring or stultifying. I like to think of these four years as a testing period where the consequences of success of failure are minimal, save as they inform the individual about how to have a satisfying and successful life.

So the best college experience by my standards is the most varied one. Let me tell you that as an arts college dean for twenty years I reviewed thousands of undergraduate programs. The narrowest and least challenging programs were more often elected by those who avoided mathematics and science, often because they had tried them and had done poorly. Some students majoring in science were pretty narrow, too, but most were not. Their interest in music, art, literature, philosophy, history, and political science was often almost as great as their interest in chemistry, physics, or biology. I can only guess--but you can all guess as well by reviewing the lives of colleagues in science--that those who do the best in science are also the ones who have the broadest range of interests. We have all observed that the students we admire most because of their interest in *our* disciplines are persons with such broad talents that they would succeed in almost any areas they elected.

I once heard an eminent scientist say that those who were good at science must by all means be a scientist. Other persons with less talents could take care of the rest of the problems of society, but, since science was the hardest to do, top talent should be used in science. Do you agree? I do not. Do we want the most difficult problems of the world and the relations among nations dealt with by persons who have not studied in the most rigorous and challenging of subjects? Or who tried studying them and found them distasteful or painful or too difficult? Would we not be better off if the capabilities for leadership of our most talented were also identified and developed as we developed their abilities to add to knowledge in science?

Before you answer that question, or think of reasons not to ask it, let me remind you of the nature of our society, and how it got that way. In the process of that review, some fundamental principles underlying our current institutions may become clearer.

Maybe governing a society committed to the concept of government with the consent of the governed was easier in the early days of the Republic, when the consenting process could occur within the four walls of a room, in a town meeting. As the franchise and the right to hold office has expanded to a much larger and more diverse population, gaining consent has become much more complicated. Today as citizens we struggle to live up to our ideals while every possible interest group forces its attention on us. As a result, we have too many purposes, too many items of agenda to attend to. How do we set priorities, how do we get on with the most important business?

With so many cries from diverse interests, the role of the leader becomes more critical. We need to allow voices to be heard, and then make decisions based on our values and priorities, not on volume. That requires leaders who can inspire us to commit ourselves to important goals, and who themselves can engender sufficient trust from others so as to have the power and the authority to do the right thing. Such leaders need to receive an excellent education, and then, as studies in the business world show, accept opportunities to learn, to test themselves, and then to act and to be judged by how well they have learned.

Would the demands placed upon leaders for preparation and for commitment be attractive to persons who find fascination in mathematics and science? Do you believe the two domains are incompatible? I remind you of the diversity among our youth talented in science. Many of them have interests and a sense of commitment entirely appropriate for a life of leadership. Would the world be better off if more leadership were exercised by the talented youth about whom we have been speaking in this conference? I think we can answer that question affirmatively.

Have you been thinking about productive scientists becoming politicians, and saying--what a waste? We must remember that leadership is exercised in many ways. America is a pluralistic society, with governmental organization and religious organizations, professional societies, private business corporations, voluntary community organizations, and all sorts of clubs, societies, trade organizations, and the like. In every career there comes a time when one wishes to influence the larger group--when the wish is to sell, persuade, convince, or at least have one's own way. Every individual with some ideas for making improvements needs the capability to communicate and convince others. Should we overlook the need for the best and the brightest to acquire these capabilities because they have great talent in mathematics and science?

You may have noticed that I am arguing for a new definition of liberal education: for an education that prepares youth for continual learning of all of the skills and capabilities required to accomplish to the fullest all of their life ambitions; for an education that sensitizes each individual to the responsibilities that must be accepted for improving the society in which we live. Too often, liberal education is defined as studying the past, of reading the classical writings, of being able to quote words appropriate to an earlier time. Small wonder our students and their parents want something more than that. But our school systems must change in order to help prepare for the leadership we require today.

Our educational system is admirably designed to help society find and develop the specialists it needs. When there is an increase in well-paying jobs for engineers, somehow the number of persons seeking engineering degrees increases, and the need is met. When our country began an ambitious space program, qualified people were found. When after World War II there was a need for many college professors, salaries went up, and qualified people began applying for the jobs. We are an adaptive society.

However, our educational system has not succeeded in preparing leaders. Does the fault lie in our schools and colleges, or somewhere else?

We are asked *ad nauseam* how was it that so many extraordinary leaders emerged at the time of our Revolution. The answer is--that was where the most exciting activity in the world was occurring. To use the vernacular, "It was the hottest game in town." Anyone would want to get into that act to help create an absolutely new government based on so lofty a set of principles? No other item had higher priority in the young Republic.

And later, do you remember how the greatest talent of the country was drawn to work on the atom bomb to get one before Hitler did--and later on space science to get to the moon before Russia did? Today, our young talent is drawn to research in semiconductors and in recombinant DNA and in the growing fields of application of these new discoveries. Many have recently discovered that careers in business can be exciting *and* rewarding, especially if their financial analyses and forecasts prove better than those of their competitors--although October 19, 1987, may have disillusioned a few!

Realistically, we cannot influence all talented young people to become scientists or mathematicians, even if they have great talent; nor can we persuade all of them to plan a life of leadership. In every generation some young persons want to be somehow different. All are not as ambitious as the persons in this room. Some however, are fully uncertain, and are easily influenced by society's campaigns. And there are enough flexible persons who do change to match the changing needs of society. As our needs for computer specialists increased, for example, hordes of students began preparing.

Students make their career plans first by examining themselves, mainly looking at their interests and their talents, and second by assessing the state of the world--namely the job market. The very best way to change student objectives is by increasing the availability and the attractiveness of lifelong jobs. Pay level is important, but opportunities for advancement and security for some are more important. A job that gives the opportunity for service attracts many. If opportunity for a lifetime of service is tied to assurances of high status and honor, and a bit of job security, few will turn down the bait.

Neither scientists nor leaders will emerge in sufficient quantity and quality in a society unless and until society rewards it, supports it, makes sacrifices for it, and gives it higher priority than anything else. Money is important, but for an idealistic youth, status, prestige and respect are critical.

A society in which we use scientific talent also requires leadership that understands science and how new developments occur. A society that can accommodate to the wonders of new discoveries is rare; new discoveries frighten most people, and often lead to movements that can only be called atavistic. Only a quality of leadership much more appropriate to our times can help our society restructure its myths and its institutions and realize the full potential of new knowledge for benefiting people.

How do we make all of this happen? Well, I say, first we must attract into leadership responsibilities persons with better talent and better education than we have seen so far.

Let us help students understand the necessity for identifying and nurturing leadership talent. A somewhat different look at history would help, in which the fateful decisions are somehow highlighted to show the knowledge available to the powerful at the time they exercised power (Herbert Simon has a computer program that does that for science). Such an analytical orientation might help us learn from history rather than merely reminding us not to repeat it.

Let us teach courses that inform about the qualities required in great leaders, the necessity for commitment, the importance of integrity, the necessity for clear vision. Let us also teach the skills of communication and of persuasion. Let us learn to relate better as humans to humans, recognizing our differing values and finding ways, by practice, for accommodating to them. A campus is a great laboratory for such learning.

Let us help students discover how to profit from experience. Provide laboratories in which they may exercise these skills both in classrooms for credit and in the student groups that assemble for various purposes.

Let us identify those who seem to possess the requisite basic capabilities who seem to be the best bets for leadership roles and encourage them to seek opportunities for development; to think of themselves as future leaders; call such persons to the attention of employers and agencies as persons of great general promise; give them opportunities to learn about leadership.

My thesis is that an educational program of this sort is precisely right for the talented youth who represent our best hopes for the future in science, technology, and mathematics. The ideal is a broad and liberal education that builds commitment and concern, an understanding of our social institutions and how they work, and that develops ability to engage the rigorous and analytical processes that characterize good science. Such a program will produce leadership for our nation not only in science and technology, but in governance and human relations as well. From this wonderful group of broadly educated scientists our nation and others can draw the leaders of the next generation with confidence, certain that they will know enough, and believe strongly enough to accomplish miracles.

Discussant Reaction:
The Importance of Developing Leadership Potential of Youth with Talent In Mathematics and Science

Earl H. Dowell

Let me cover the information in my written response briefly and then get on to some of the interesting things Dr. Clark had to say this morning. Dr. Clark's central thesis is that there are some very bright people studying science and mathematics and engineering today. This is true, and it's been true for at least a half century. However, recently there's been quite a shift within that spectrum. A major demographic change among undergraduates in the U.S. over the last 10 or 15 years has been that many more bright students are now studying engineering rather than science. Twenty five years ago the pecking order was clearly physics first, then mathematics, chemistry, biology, and so on. Now it's engineering, followed by biology, physics, etc. In any event, within this total spectrum there are some very, very bright students, disproportionately so compared to the general college population. I think it's fair to try to encourage these people to do something more than solve equations and make measurements in the laboratory. Shouldn't we encourage them to be leaders in the broader sense? Clearly, the answer to that question is yes.

How do we go about encouraging bright students to become leaders? Before addressing that question let me suggest how I think we're doing, or not doing so well. I will take as my examples the one that Dr. Clark said that we shouldn't take, namely CEO's in major corporations and Presidents of the United States. Those are not good examples according to Dr. Clark, and I think he's right in some ways, but he's wrong in another way. The way in which I suggest he's wrong is this: many of us might at one time have thought that we wanted to be the CEO of General Electric or we might have even wanted to be President of the United States. These people do serve as role models. What would a young person think looking at the presidential candidates today, with respect to wanting to be President of the United States? I don't know the answer to that, although I can hazard a guess. In any event, let's look at CEO's of major corporations and Presidents of the United States.

CEO's of major corporations. I've seen a couple of studies which suggest that about one-fourth, perhaps as many as one-third, of the CEO's of the Fortune 500 companies in the U.S. have engineering degrees. Is that many or is that few? Only 8 percent of all college graduates are engineers, so therefore I claim the percentage of engineers among CEO's is large. Now it is true that those people who have engineering degrees may also have MBA degrees. They also may have law degrees, and frequently do. If you plan to become the CEO of a major corporation, somewhere along the line after your engineering degree you may pick up a law degree or an MBA. So engineers, in fact, are present in positions of Chief Executive Officer of Fortune 500 companies in disproportionate proportion to their presence in the general population of the university, but they may well have an advanced degree in another field as well.

What about Presidents? Which Presidents of the U.S. have been engineers? Herbert Hoover--a bad role model, perhaps, but nevertheless the one that everyone remembers, at least of my generation. Jimmy Carter--if one were to ask people to name engineers who became president, most would recall Jimmy Carter and Herbert Hoover. Anyone else? What about Dwight Eisenhower? Over the last several

decades, after the accreditation of engineering programs became the norm, military academies decided that they were offering an engineering degree. So, if you are a graduate of one of the military academies you are most likely an engineer. Thus we could include Dwight Eisenhower and we could also include George Washington, who really was an engineer. But those are debating points perhaps, and you may say that we shouldn't count Jimmy Carter, either. Someone might recall Thomas Jefferson, who was a Renaissance man and virtually everything, including an engineer and scientist. Nevertheless, the real point is that we've had very few engineers or scientists as Presidents of the U.S., at least in the usual sense. You do remember, I'm sure, that at present we have as President an actor who is also a major in Economics from Eureka College, a small church-related liberal arts college in the state of Illinois. Richard Nixon is a lawyer and I haven't found out what his undergraduate degree was. Lyndon Johnson was a school teacher with a degree in education from Southwestern State Teachers College. John Kennedy had a degree in some aspect of social science from Harvard. So we haven't had many engineers or scientists as presidents of the U.S., a really poor showing there.

I would recall for you that there are other CEO's in the political area, governors of states, and we do a little better here. The current governor of North Carolina, James Martin, has a degree in chemistry, a Ph.D. from Princeton. He did his post doctorate at Duke, and was on the faculty of Davidson College for several years. His predecessor, Jim Hunt, is known as a lawyer, but his undergraduate degree is in engineering from North Carolina State University. John Sununu from New Hampshire has a Ph.D. in engineering from the Massachusetts Institute of Technology (MIT) and was the Associate Dean of Tufts before he went into politics in New Hampshire. At the level of governor we do a little better, particularly in recent times.

Nevertheless, the question that was raised by Dr. Clark is still clearly stated; in which professions can the members count to their advantage the effort to make the good fight, run the good race for public office, and are defeated? Lawyers gain by virtue of running for public office, even if they lose the race. Engineers and scientists, on the other hand, would distinctly lose if they were defeated in the race for office. Therefore, entering politics is a high risk move for an engineer or scientist. Given the fact that there's one thing that many young people crave, namely security, it is not surprising to me that young people who have engineering or science backgrounds do not choose by and large to run for public office.

Perhaps it isn't surprising that Jim Martin and John Sununu came from the security of tenured faculty positions at Davidson and Tufts and moved from there, probably on a leave of absence, to serve in Washington or Raleigh or wherever. So maybe the message is we should encourage our engineering and science faculty to run for public office. We have a case locally, David Price. Mr. Price is currently on leave from Duke University, is a professor of political science, or of public policy, and is serving as our congressman. Clearly it isn't a bad thing to do to enhance your credentials professionally. My conclusion with respect to whole issue of why we don't have more leaders in the public sector who have backgrounds in engineering and sciences is that we shouldn't realistically expect people to run for public office when the career risk is so high.

Let me now turn to a couple of other points that Dr. Clark raised. Career selection: young people today, I would suggest, are largely selecting careers based as a desire status, money, and security. We can wish it were otherwise, but that's the way it is. A young person who has all of those already may opt for other values, but if in their perception they don't have a sufficient amount, then their college major selection and their career path selection will be greatly influenced by the perceived deficiency in one or more of those areas.

Dr. Clark suggested that talented executives tested better at a later age. That clearly would be true if you were testing them with respect to economics, accounting, or world history; I don't think it would be true with respect to differential equations. So I think that Dr. Clark's statement has to be tempered by the fact that the tests were not likely to assess areas of science and mathematics, at least not in great depth.

With respect to self-selection of leaders, I think although many people would enjoy the prerogatives of being a leader, there are relatively few who would care to have the responsibilities. When you are a leader, you are much more conscious, I would suggest, of the responsibilities than you are of the prerogatives. I would also suggest to you that to the extent that leaders are not self-selected, but selected by others, the quality of those leaders is greatly influenced by the quality of the followers. I think the quality of our Senators and Congressmen and even Presidents over the last several years is, if anything, above the general quality of the people who voted for them. So I don't think we have any real cause to complain.

Dr. Clark mentioned some statistics about dollars being spent by the universities versus dollars being spent by corporations on education of their employees. It's true that corporations are spending more money on the education of their employees than is being spent in universities in this country, which may seem surprising at first. However, there are about a hundred million people employed in this country and there are about four million people in our universities. Therefore it's not altogether surprising that we're spending more money on the education of a 100 million people than we are on the education of 4 million people.

Liberal education and its rationale. Liberal education, as we know it in this country, is largely vocational education as it was originally defined for the British ruling class about a century ago. A liberal education is often put forth as the choice of the person who isn't interested in grubby things like money, and careerism, and all those other nasty things that some people are interested in. In fact, liberal education was very much career oriented when it was established.

Graduate education and the selection of degree path, MBA, Ph.D, JD, MD, and all the rest of it. As Dr. Clark pointed out we have a very interesting paradox, although it is not really a paradox once you think about it. How many people know what an engineering or science graduate student is paid to be a graduate student at Duke, or Johns Hopkins, or Princeton, or Stanford? About $12,000 plus free tuition. Now that's not much compared to the $30,000 they could make if they had a job. Thus some allege the reason they don't pursue graduate programs is because of the difference between the $12,000 and the $30,000. On the other

hand, $12,000 when combined with the $10,000 for tuition the $22,000 is a lot more than the law student, the business student, or the medical student is getting.

Consider the engineering or science student who has the choice between going to graduate school versus going on for an MBA for example. For the two years s/he would be in the MBA program rather than a graduate program, s/he would be in the red to the tune of a differential of $22,000 per year. Yet students are doing that in considerable numbers. Why? Dr. Clark suggests that they expect to make it up later on. Whether they do or not remains to be seen. But I agree that's the expectation and that's the reason for their decision.

Those are my comments on the issues raised by Dr. Clark. Maybe I've said something provocative that someone else will wish to challenge, correct or comment upon.

Discussant Reaction:
The Importance of Developing Leadership Potential of Youth With Talent in Science and Mathematics

Edward. G. Sherburne, Jr.

I found Dr. Clark's comments very suggestive, particularly some of his assumptions about leaders. I want to talk about them later on, but before I do, I think that I should explain a bit about my perceptions of talent, as I am neither an academic nor a psychologist.

Science Service, the organization for which I work, is a nonprofit agency whose largest activity is the publication of *Science News*, a weekly with a 200,000 circulation. Half of our subscribers are scientists and engineers who read the magazine for news out of their own field of specialty, and the others are "interested laymen."

Science Service has three other programs, all of which are at the precollege level. The Westinghouse Science Talent Search is a scholarship program which selects the winners on the basis of the quality of an independent research project in science, engineering or mathematics, with only secondary emphasis on academic achievement. The International Science and Engineering Fair is the "world series" of science fairs, and is much larger in terms of participation. The common thread between the two programs is that students are judged on the basis of a research project. The third program is the Directory of Student Science Training Programs for High Ability Precollege Students. This lists programs that provide course opportunities (like TIP) or research opportunities. The current 1988 Directory lists 507 programs, mostly sponsored by colleges and universities.

As a result of the kinds of precollege programs that we have, we look at talent in a rather different way from most of you. Essentially, we define talent in terms of scientific performance ("doing" science) rather than academic performance (grades and test scores).

To give you an idea of the kinds of students we are involved with in our programs, I want to read from a letter written by a scientist mentor of one of our students. In our two competitions, we have an increasing number of students who have done their research in a scientist's laboratory. So we ask the scientists to answer some questions about the students, and use these answers to help in evaluation.

Here are the replies to three questions:

1. Question: How did the student get the idea for the research?

Answer: He sought my assistance to carry out research in plasma physics in general and in double layers in particular. He explained to me that he became interested in this subject after reading several journals and one magazine article. Although the general focus of the research was entirely his, the actual experiment was decided upon jointly after several months of literature research.

2. Question: How independently did he work?

Answer: He worked very independently. He built experimental components, operated high vacuum equipment, assembled and maintained electronic diagnostic equipment, planned and executed all aspects of experimentation procedure, and individually analyzed all data.

3. Question: What did the student do to show creativity and ingenuity?

Answer: He formulated and attacked a completely new problem in plasma equilibrium of magnetized plasma. He was able to conceptualize the role of magnetic fields and their influence on equilibrium plasma and test several hypotheses as characterized in an entirely new experimental configuration which demonstrated a clearly measurable relationship between magnetic and density topology, and postulated the physical principle that may be responsible for this relationship.

This student was a twelfth grader, and probably did some of the research before the twelfth grade. So you can see that we are dealing with a kind of person who is something more than your high academic achiever.

I would like to support this anecdotal evidence by a study of the Honorable Mentions of the Westinghouse Science Talent Search[1]. As I have already indicated, the STS is a scholarship program that makes the selections on the basis of the quality of an independent research project in science, engineering or mathematics, with secondary emphasis on academic achievement.

In short, the evaluation is on the basis of the student's ability to use the knowledge possessed to "do" science in a way that is analogous, though not at such a sophisticated level, to what a professional scientist does. To use a sports analogy, one does not test a student's ability to play tennis by giving a paper and pencil test. One puts the student on the tennis court to play so that performance can be judged.

The study looked at three hundred Honorable Mentions in the STS a number of years ago. These Honorable Mentions were selected as usual on the basis of their research papers, that is, scientific performance. These three hundred were compared with three hundred selected from the total pool of entries on the basis of academic achievement as indicated by a weighted score from grades, rank in class, etc.

The two groups were compared to see how many students were in both groups. The results: only one-third of the students chosen on the basis of scientific achievement were also chosen on the basis of academic achievement. Conversely, only one-third of the students chosen on the basis of academic achievement had high enough scientific performance ratings to be chosen by that model. From this, I conclude that intelligent behavior in the classroom is not the same as intelligent behavior in the laboratory.

How can this be? If one looks at the laboratory--"doing science"--as opposed to doing classroom work, one sees some major differences. In a research project,

you have long closure instead of the short closure typical of most academic work. You have real problems in a research project instead of the contrived problems of the classroom. You have complex problems in a research project, far more complex than any kind of problem that you can have in an examination. You have a whole different attitude toward failure and success. You can't fail in the classroom. In science you're very good if you ever succeed the first time around.

Thus, one can see that students who are successful in one context may not be as successful in the other. This has profound implications in regard to the future supply of scientists and engineers, a topic which is one of the principal concerns of this meeting.

A recent report by the Government-University-Industry Roundtable[2] states that the nation will soon face "a potentially serious problem in quality and quantity of technical personnel" unless more students are recruited into science and engineering. The group found that the number of twenty-two year-olds is expected to drop by more than twenty-five percent by the end of the century, with corresponding decreases in science and engineering students. To simply keep up with the 1985 level of twenty-two year-olds earning science and engineering baccalaureates, "the degree award rate would have to increase by thirty percent in the 1990's," the report says.

The situation would be relatively simple were it not for the fact that future scientists and engineers are recruited from essentially the same pool of high academic achievers as are in such fields as medicine and law. As the size of the age cohorts go down, the competition for majors in various disciplines can only be expected to become greater. And if we add future leaders to the groups to be recruited to the pool, the situation becomes even worse.

The first way to improve the supply is to increase the size of the talent pool as usually defined--high academic achievers. At the present time, it is largely made up of white males. It is always possible, of course, to upgrade their achievement level to make the pool larger, but the great potential for increase is among girls and minorities. This possibility is increasingly recognized, and a considerable amount of effort is being directed toward implementing it.

A second possibility is to increase the productivity of scientists and engineers. At the present time, all scientists and engineers are usually treated as though they were equally productive. This is by no means the case. In science, for example, between ten percent and fifteen percent of all scientists produce roughly fifty percent of the literature[3]. If the number of highly productive scientists could be increased, the research productivity would be increased far beyond their proportion to the total number of scientists. I cannot make any suggestions as to how to do this, but I do feel that productivity should be considered as well as numbers.

But neither of these possible solutions seem to me to take into account what I see to be a basic problem. What worries me is that the pool from which future professionals will be drawn is one whose sole criterion is academic achievement. The implication here is that intelligent behavior can be defined in terms of intelligent classroom behavior, and that intelligent classroom behavior is considered

to be the same as intelligent scientific, engineering, medical, legal, business, industrial, military, etc., behavior. And it is considered to be the same thing as the behavior of the leaders in the occupations such as the ones I have mentioned. This is something with which I strongly disagree.

I refer to the study of the Honorable Mentions in the Science Talent Search, where the scientific achievers and the academic achievers were substantially different students. This is not to imply that academic achievement is unimportant. Mansfield and Busse[4] comment on the "threshold effect" that has been suggested by some psychologists. This suggests that there is a threshold academic ability level required for a discipline, but that beyond this level, additional academic achievement is not as important as the possession of such characteristics as creativity or motivation. In a sense, one could say that scientific performance guarantees the possession of the necessary academic achievement, as scientific research cannot be done without scientific knowledge. But on the other hand, it does not matter how much you know if you don't use it effectively.

The characteristics that help a person in one occupation are not necessarily the same for all occupations, and are not necessarily possessed in the same amount in occupations where they are the same. Robert Sternberg, in his "Beyond IQ"[5], talks about the context of intelligent behavior, and that "intelligence cannot be completely understood outside a sociocultural context and may in fact be different for a given individual from one culture to another." And he goes on to talk about "the weights, or importance, of the various aspects of mental hardware and software as they apply to defining intelligent behavior." In other words, intelligent behavior for the scientist in the laboratory is not the same thing as intelligent behavior for the leader in politics or business. And yet we are using this criterion as the principal means of identifying potential scientists, leaders, lawyers, politicians, etc.

I was talking about this to Betty Vetter, of the Commission on Professionals in Science and Technology[6], and she remarked that "the problem is that we do not know how to recognize talent potential, and so we use all kinds of substitutes such as grades and test scores."

I am especially concerned about all this in regard to leaders. In "Genius, Creativity and Leadership," Dean Keith Simonton[7] describes a study he did of the relationship between formal education and achieved eminence of leaders. He reports that "for leaders, fame is strictly a linear and negative function of formal education level. The highest ranked politicians, generals, admirals, reformers, diplomats, revolutionaries, and religious innovators have the least formal education. Evidently, higher education does not contribute to leadership potential." As he went back in history quite a way, one can speculate that this does not apply now. But it is very suggestive.

Why might this be so? I would contend that it is because there are characteristics other than those needed for achievement in formal education that affect success. For example, leaders tend to have charisma--the power or personal quality that gives an individual influence or authority over large numbers of people. We certainly don't know how to teach charisma, we don't know how to

test for it, and we probably don't even know whether it is innate or learned. But our lack of knowledge about it does not mean that we should ignore it.

There are many other characteristics that contribute to adult occupational success that tend to be ignored as well. Perhaps the most important is motivation. To quote Sternberg again, he says that "differences in motivation may account for large shares of differences in observed performance, regardless of the level of the performance."

The point of all of this is that I think that the use of academic achievement to identify talent is too restrictive. I think that we have to include a whole host of other characteristics, which at least beyond the threshold level, are really what bring about adult occupational success.

In the terminology of Thomas Kuhn in *The Structure of Scientific Revolutions*, the paradigm has to change[8]. We have to move beyond seeing talent only in terms of intelligent behavior in the classroom, removed from any sort of relationship to real-world experience. It is twenty-two years since Donald Hoyt[9] published his classic review of forty-six studies on the relation of academic achievement and adult occupational success. In it, he concluded that despite the limitation of these studies, we can safely conclude from them that college grades have no more than a very modest correlation with adult success, no matter how defined.

I hope that we don't have to wait twenty-two years more before we do something.

Recommendations

The recommendations that I will present are made with a bias that probably sets me apart from most of the participants in this meeting. So before I go ahead, I should like to describe very briefly what these biases are:

- Intelligent behavior in the classroom is not the same as intelligent behavior in the laboratory, or to put it more broadly, as intelligent behavior in an adult occupation.

- Academic achievement does not predict adult occupational success.

- Various occupations have academic threshold levels which largely determine entry, but academic achievement beyond these levels does not contribute to adult occupational success.

- Personality attributes and other variables strongly affect adult occupational success once the threshold level of academic achievement has been reached, and it is these variables which account for different productivity levels of scientists.

I should like to make the following recommendations:

1. The database being considered should be called something like the National Database on Adult Success in Mathematics, Science and Technology, rather than the National Database for the Academically Talented in Mathematics, Science and Technology.

2. The academic information contained in the database should be related to at least the upper 15 percent of precollege students and not restricted to the 3 percent or whatever level is used to designate gifted and talented.

3. The database should include non-academic data, that is, data on the multitude of other variables that contribute to adult occupational success. This might include:

   a. Personality attributes: creativity, persistence, independence, initiative, etc.

   b. Motivation.

   c. "The significant others"--teachers, mentors, peers. This should include information on role models.

   d. Family. Our experience with the Science Talent Search Asian winners strongly suggest that family can be a major variable in achievement.

   e. Precollege extracurricular experiences, especially contests. These include the Science Talent Search, the International Science and Engineering Fair, the International Olympiads (mathematics, physics, chemistry), etc.

   f. Identification of successful scientists so that retrospective studies can be done on their life history. A classic example "Developing Talent in Young People," Benjamin S. Bloom, editor, Ballantine Books, 1985.

   g. Follow-up to give career choice of individuals and their eventual occupation.

   h. Record of achievements: awards, membership in the National Academy of Science, etc.

   i. Some tie-in with the Citation Index as a means of showing adult success and particularly, research productivity.

   j. A collection of the data from other studies (not just the studies themselves), so that this data can be reused. This is done in public opinion research, and while I assume that it might be more difficult in this instance, I feel that it should be considered.

Notes

1. Edgerton, H. (1973). Identifying high school seniors talented in science. Science Service, Washington, DC. Mimeo.

2. Nurturing Scientific and Engineering Talent. (1987). Government-University-Industry Roundtable. National Academy of Sciences.

3. Cole, J. (1987). Women in science. In D. G. Jackson and J. P. Rushton (Eds.), *Scientific Excellence*. Sage Publications.

4. Mansfield, R. and Busse, T. (1981). *The psychology of creativity and discovery*. Nelson-Hall.

5. Sternberg, R. (1985). *Beyond IQ: A triarchic theory of human intelligence.* Cambridge, Massachusetts: Cambridge University Press.

6. Vetter, B. Executive Director, Commission on Professionals in Science and Technology. Personal Communication.

7. Simonton, D. (1984). *Genius, creativity, and leadership*. Harvard University Press.

8. Kuhn, T. (1970). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

9. Hoyt, D. (1966). College grades and adult accomplishment--A review of research. *The Educational Review*, Winter.